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Review Article

Validity of Nutritional Screening Tools for Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis

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A B S T R A C T

Objectives: The aim of this systematic review was to summarize the validity of nutritional screening tools to detect the risk of malnutrition in community-dwelling older adults.
Design: A systematic review and meta-analysis. The protocol for this systematic review was registered in the PROSPERO database (CRD42017072703).
Setting and participants: A literature search was performed in PubMed, EMBASE, CINAHL, and Cochrane using the combined terms "malnutrition," "aged," "community-dwelling," and "screening." The time frame of the literature reviewed was from January 1, 2001, to May 18, 2018. Older community-dwellers were defined as follows: individuals with a mean/median age of >65 years who were community-dwellers or attended hospital outpatient clinics and day hospitals. All nutritional screening tools that were validated in community-dwelling older adults against a reference standard to detect the risk of malnutrition, or with malnutrition, were included.
Measures: Meta-analyses were performed on the diagnostic accuracy of identified nutritional screening tools validated against the Mini Nutritional Assessment-Long Form (MNA-LF). The symmetric hierarchical summary receiver operating characteristic models were used to estimate test performance.
Results: Of 7713 articles, 35 articles were included in the systematic review, and 9 articles were included in the meta-analysis. Seventeen nutritional screening tools and 10 reference standards were identified. The meta-analyses showed average sensitivities and specificities of 0.95 (95% confidence interval [CI] 0.75–0.99) and 0.95 (95% CI 0.85–0.99) for the Mini Nutritional Assessment-Short Form (MNA-SF; cutoff point ≤11), 0.85 (95% CI 0.80–0.89) and 0.87 (95% CI 0.86–0.89) for the MNA-SF-V1 (MNA-SF using body mass index, cutoff point ≤11), 0.85 (95% CI 0.77–0.89) and 0.84 (95% CI 0.79–0.87) for the MNA-SF-V2 (MNA-SF using calf circumference instead of body mass, cutoff point ≤11), respectively, using MNA-LF as the reference standard.
Conclusions and Implications: The MNA-SF, MNA-SF-V1, and MNA-SF-V2 showed good sensitivity and specificity to detect community-dwelling older adults at risk of malnutrition validated against the MNA-LF. Clinicians should consider the use of the cutoff point ≤11 on the MNA-SF, MNA-SF-V1, and MNA-SF-V2 to identify community-dwelling older adults at risk of malnutrition.

The proportion of individuals over the age of 65 years worldwide is projected to rise to 22% by 2050.[1,2] Aging may induce malnutrition due to multiple factors, such as loss of appetite, oral impairment,[3] taste and smell, drug interactions, and social isolation.[4] Malnutrition is associated with a range of negative health outcomes,[5,6] such as low quality of life, frailty,[6] loss of autonomy, morbidity, higher frequency of

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hospital admissions, and mortality.[7–10] In community-dwelling older adults, the prevalence of malnutrition is reported to range between 2% and 42%.[6,11] The wide variation in the prevalence of malnutrition may be due to the various nutritional screening tools, as well as the many reference standards used to validate these nutritional screening tools.[12–14]

The absence of a gold standard to define the risk of malnutrition and actual malnutrition has led to different approaches in validating nutritional screening tools. A recent review on the validity of nutritional screening tools used in older adults in the community, residential care, rehabilitation, and hospitals identified a total of 34 nutritional screening tools and 17 different reference standards.[15] The most widely used and acceptable reference standards were the Mini Nutritional Assessment–Long Form (MNA-LF) and the clinical assessment given by a nutrition-trained professional.[15] To our knowledge, no meta-analysis has been performed on the diagnostic accuracy of nutritional screening tools used to identify community-dwelling older adults at risk of malnutrition.

This study was conducted as part of the Physical Activity and Nutrition INfluences In aging (PANINI) network research[14] and aimed to perform a systematic review of all available nutritional screening tools validated against reference standards in community-dwelling older adults. We reported on the validity of the cutoff points used on the nutritional screening tools to identify those at risk of malnutrition and with malnutrition. Second, we performed a meta-analysis on the diagnostic accuracy of identified nutritional screening tools validated against the Mini-nutritional Assessment–Long Form or a health professional's rating of nutritional status.

Methods

The protocol for this systematic review was registered at PROSPERO International prospective register of systematic reviews (Registration number: CRD42017072703). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to guide the reporting of this review.[16]

Search Strategy

A systematic search was performed by a librarian and the articles identified were obtained through electronic searches of the following databases: PubMed, EMBASE, CINAHL (via Ebsco), and Cochrane. The time frame for the search was from January 1, 2001 to May 18, 2018. The search strategy combined the terms "malnutrition," "aged," "community-dwelling," and "screening", and synonyms. Language was not restricted in the search strategy; publications that were not in English were later excluded. The reference lists of the identified articles were further searched for relevant publications. The search strategy syntax can be found in Appendix 1.

Selection Process

The relevant titles and abstracts, then the full texts, were independently screened for eligibility by 2 authors (JI and MB) using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia; www.covidence.org). When conflicts or discrepancy arose between the 2 authors, a third author (SY) made the final judgment of the articles.

Inclusion Criteria and Exclusion Criteria

For the purpose of this systematic review, we included all nutritional screening tools validated against a reference standard. If a nutritional screening tool had multiple versions, such as the Mini-Nutritional Assessment Short-Form (MNA-SF) or Seniors in the Community: Risk Evaluation for Eating Nutrition (SCREEN), then each version of the tool was assessed independently. Our rationale for not grouping similar tools together was because, despite their similarity, these tools differ importantly in their measurements, questions, and scoring methods; therewith they might have different construct validities. As there is no gold standard for the assessment of malnutrition, the MNA-LF, a detailed nutritional assessment by a dietitian or physician, and Subjective Global Assessment (SGA), were considered as identifiers of patients with the risk of malnutrition. The European Society of Parenteral and Enteral Nutrition (ESPEN) recommend the use of MNA-LF, SGA, or Patient Generated Subject Global Assessment (PG-SGA) to facilitate the assessment of malnutrition.[17] A detailed nutritional assessment should include medical, social, psychological, and nutrition history, as well as energy and fluid requirements.[17]

The criteria for selecting articles included the following: validation studies of nutritional screening tools developed to identify the risk of malnutrition or malnutrition with description of psychometric properties (sensitivity, specificity, and criterion validity). Community-dwelling older adults were defined as follows: individuals living at home with a mean/median age of >65 years who attended hospital outpatient clinics, day hospitals, or community centers, or participated in a population study.

The articles were excluded if the population being screened for malnutrition consisted of fewer than 50% community-dwelling older adults. In addition, articles were excluded if the screening tool included laboratory values, such as Prognostic Nutritional Index, Controlling Nutritional Status (CONUT), or Maastricht Index. Conference abstracts, systematic reviews, and letters to editors were also excluded.

Data Extraction

The data were independently extracted by 2 authors (JI, MB) for each eligible article. The extracted variables included the following: author, year of publication, country origin of the research population, study population, number of included individuals, recruitment strategy, percentage of male individuals, age of individuals, nutritional screening tool and its version, the reference standard, and the prevalence of community-dwelling older adults at risk of malnutrition and those with malnutrition as determined by the reference standard. If the articles included a mixed population (eg, hospitalized and community-dwelling older adults) and data were available on both populations, then only data pertaining to the community-dwelling older adults was extracted.

As part of the systematic review, to evaluate the diagnostic accuracy of the nutritional screening tools, the following data were extracted from the eligible articles: cutoff points used to identify individuals at risk of malnutrition or with malnutrition, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), area under the curve (AUC), correlation coefficient, and kappa. Validity of a screening tool was defined as good if sensitivity ≥80%, specificity ≥80%, AUC ≥0.8, correlation coefficient ≥0.75, and/or kappa ≥0.6; fair if sensitivity ≥50% but <80%, specificity ≥50% but <80%, AUC 0.6–0.8, correlation coefficient 0.40–0.75, kappa 0.40–0.6; and poor if: sensitivity <50%, specificity <50%, AUC <0.6, correlation coefficient <0.40, kappa <0.40.[18]

Methodological Quality of Extracted Papers

To assess the methodological quality of the included studies, the Quality Assessment of Diagnostic Accuracy Studies–version 2 (QUADAS-2) was used.[19] The signaling questions used to assess the quality of the studies are in Table 1.

Table 1
QUADAS Signaling Questions

- Did the study involve inappropriate exclusions?
- Were the index test results interpreted without knowledge of the results of the reference standard?
- If a threshold was used, was it prespecified?
- Is the reference standard likely to correctly classify the target condition?
- Were the reference standard results interpreted without knowledge of the results of the index test?
- Did all patients receive a reference standard?
- Did all patients receive the same reference standard?
- Were all patients included in the analysis?

Statistical Analysis for the Meta-analysis

Revman 5.3 (Versuib 5.3. Copenhagen: The Nordic Cochrane Centre, TCC, 2014) was used to calculate true positives (TP), false positives (FP), true negatives (TN), false negatives (FN), and PPV and NPV from the values of sensitivity, specificity, and prevalence reported in the articles. Symmetric hierarchical summary receiver operative characteristic (HSROC) models were used to jointly estimate sensitivity and specificity, positive and negative likelihood ratio, and diagnostic odds ratio (DOR) using STATA statistical software, version 14.1 (StataCorp, College Station, TX). We were unable to pool estimates when the number of studies was fewer than 4.[20] Instead, forest plots were used to display sensitivity and specificity for all nutritional screening tools validated against the MNA-LF, a health professional's rating of nutritional status or SGA.

Results

Study Selection

The search yielded 12,103 citations, including 4394 duplicates; an additional 4 articles were identified from checking the reference list of relevant articles and review articles. After title, abstract, and full text screening, 7678 articles were excluded, resulting in 35 articles that were included in this systematic review and 9 articles were included in the meta-analysis. The article selection flow is shown in Figure 1.

Study Characteristics

The study characteristics are presented in Table 2. The median sample size was 283 individuals (Interquartile range [IQR] 199 to 754, range 45–22,007), the mean age was 74 years (SD ± 3.5, range 67–86 years), and included a median of 39% male individuals (IQR 35% to 47%, range 19%–59%). The median prevalence of malnutrition as determined by the reference standard was 5% (IQR 2% to 15%), and the median prevalence of individuals at risk of malnutrition was 32% (IQR 23% to 44%). Seventeen malnutrition screening tools were identified: Mini-Nutritional Assessment Short-Form (MNA-SF),[21,23,29,43–45,52] MNA-SF-V1 (MNA-SF using body mass index [BMI]),[24,31,34,35,37,41,42,46,47,50] and MNA-SF-V2 (MNA-SF using calf circumference instead of BMI),[31,35,37,40,42,47,50,53] Self-MNA,[26] MNA-LF,[12,25,27,36,44,54] Malnutrition Risk Screening Tool (MRST),[45] South African Tool,[22] DETERMINE Checklist,[23] SGA,[12,36] Nutritional Risk

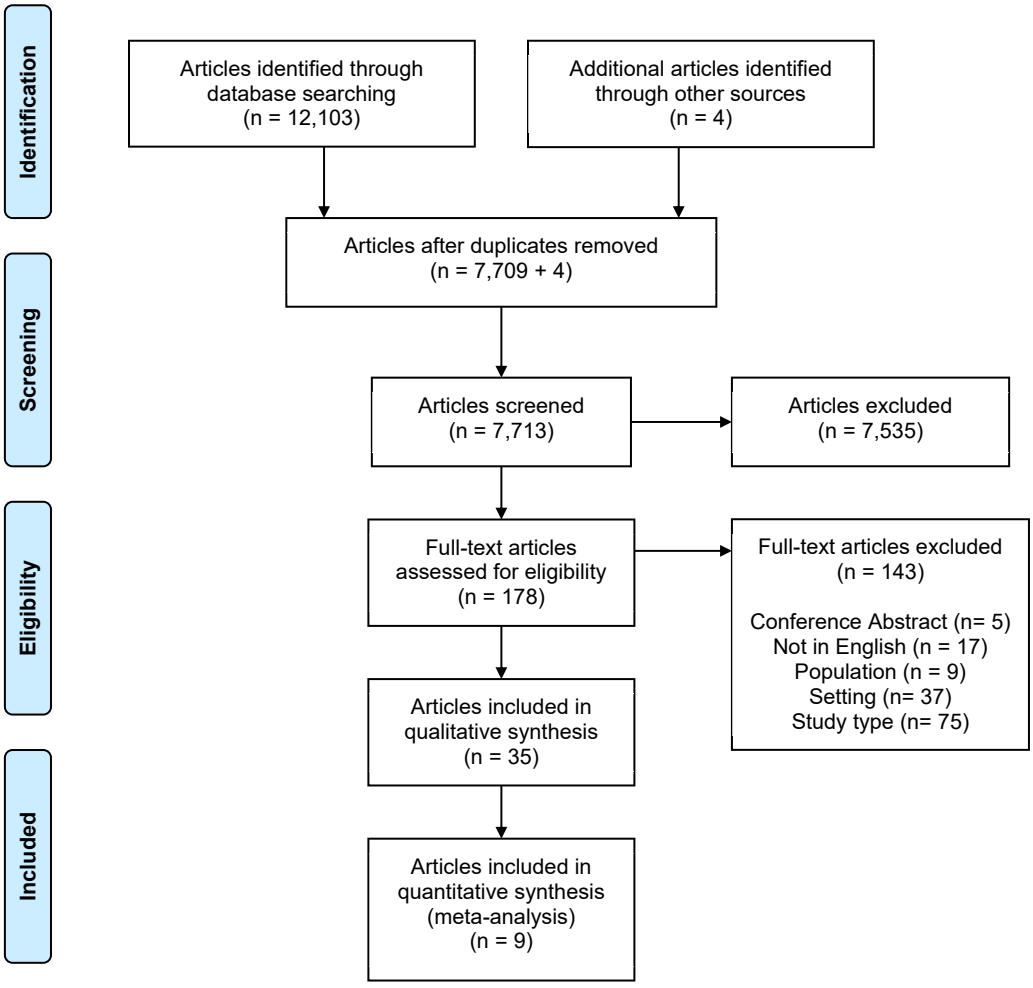

Fig. 1. PRISMA flowchart of the article selection procedure for the systematic review.

Table 2
Characteristics of Study Populations and Nutritional Tools Included in the Systematic Review

Author, Year	Country	Population	*n*	Recruitment Strategy	Male, %	Age, year ± SD	Screening Tool	Reference Standard	Prevalence, %
Borowiak, 2003[21]	PL	CD	160	Community center	27	74.1 ± 6.2	MNA-SF	MNA-LF	RM: 45
Charlton, 2005[22]	ZA	85% CD 15% NH	283	Church, luncheon clubs, community/aged care facilities	19	71.5 ± 8	South African Tool	MNA-LF	RM: 50.4 M: 5
Charlton, 2007[23]	ZA	85% CD 15% NH	283	Church, luncheon clubs, community health centre, aged/day care facilities	19	71.5 ± 8	MNA-SF DETERMINE	MNA-LF	RM: 50.4 M: 5
Cuervo, 2009[52]	ES	CD	22,007	Community Pharmacy	36	75.2 ± 6.8	MNA-SF	MNA-LF	RM: 25.4 M: 4.3
Cuervo, 2009[54]	ES	CD	22,007	Community Pharmacy	36	75.2 ± 6.8	MNA[*] MNA[†,‡]	MNA-LF	RM: 25.4 M: 4.3
De la Montana, 2011[24]	ES	CD	728	Social Workers	36	80.7 ± 7.4	MNA-SF-V1	MNA-LF	RM: 57.5 M: 12.5
Donini, 2013[25]	IT	77% CD 23% NH	522	Geriatric facilities, nursing homes	34	76.9 ± 7.5	MNA−P MNA-CC-MAC	MNA- LF	RM: 38 M: 19
Donini, 2018[26]	IT	CD	226	24 GP offices	45	75.1 ± 8	Self-MNA	MNA-LF MNA-SF	RM: 32 M: 6
Ghimire, 2017[27]	NP	CD	242	House to house/ random sampling	46	69.8 ± 7.4	MNA-LF[§]	BMI	RM: 64.9 M: 24
Harada, 2017[28]	JP	OP	229	Attending OP clinic	48	66.8 ± 10.2	SNAQ SNAQ[revised]	CONUT	RM: 8.7 M: 1.7
Harris, 2008[29]	WAL	CD	100	Sheltered accommodation	31	79.3 ± 6.3	MNA-SF MUST	Rating (D)	RM: 10
Htun, 2015[30]	JP	CD	1921	NR	51	73.0 ± 5.5	SCREEN II[§]	GNRI MNA-SF	MNA-SF RM: 34.7 GNRI RM: 5.6
Kaiser, 2011[31]	DE	CD	272	Newspaper, posters, GP	33	80.9 ± 5.7	MNA-SF-V1 MNA-SF-V2	MNA-LF	RM: 11 M: 0
Keller, 2001[32]	CA	25% SH 25% SA 18% DH 38% CD	128	Housing workers, nutrition seminars, Dietitians, mail, advertisement	27	74 ± 9.1	SCREEN version I	Rating (D)	RM: 28.1 M: 19.5
Keller, 2005[33]	CA	CD	193	GP, newspaper, posters, letters	38	65–74	SCREEN II SCREEN II[‖]	Rating (D)	RM: 66.8 M: 18.7
Kiesswetter, 2014[34]	DE	CD	309	Health services/ insurers, nursing/ counselling services, day care	36	80.9 ± 7.9	MNA-SF-V1	MNA-LF	RM: 57.6 M: 13.6
Kostka, 2014[35]	PL	CD	1744	Random selection from urban and rural GPs	U: 31 U: 40	U: 71.7 ± 5.3 R: 73.0 ± 6.6	MNA-SF-V1 MNA-SF-V2	MNA-LF	U - RM: 29.9 U - M: 1.7 R - RM: 40.7 R - M: 7.6
Kozakova, 2012[12]	CZ, SK	CD	120	Home care agencies	61	73.2	MNA-LF SGA MUST	NR	NR
Kozakova, 2014[36]	CZ, SK	SH	470	Nursing home care	46	77.2	MNA-LF MUST SGA	BMI	NR
Lee, 2012[37]	TW	CD	2948	Population-based survey	55	65–74 (56.4%) 75–84 (36.9%) ≥85 (6.7%)	MNA-SF-V1[§] MNA-SF-V2[§]	MNA-LF[§]	RM: 16.8 M: 3.4
Leipold, 2018[38]	AU	CD	160	Community rehabilitation	42	74.0 ± 12.0	MST	SGA	RM: 31.8 M: 2.5
Leistra, 2013[39]	NL	OP	780	6 teaching, 1 university, 2 general hospitals	NR	NR	MUST SNAQ	weight loss and BMI	RM: 43.9 M: 50
Lera, 2016[40]	BR, CU, CL, MX, UY	CD	5226	Household survey, Health, Well-Being and Aging Study	36	71.7 ± 8.0	MNA-SF-V2	MNA-SF-V1	RM: 29.9–38.6 M: 1.1–12.4
Lilamand, 2015[41]	FR	DH	265	GP, specialist consultants/ oncogeriatrics	33	81.5 ± 5.8	MNA-SF-V1	MNA-LF	RM: 22.8 M: 1.9

(*continued on next page*)

Table 2 (*continued*)

Author, Year	Country	Population	*n*	Recruitment Strategy	Male, %	Age, year ± SD	Screening Tool	Reference Standard	Prevalence, %
Lozoya, 2017[42]	ES	CD	660	12 Community centres	48	74.3 ± 6.6	MNA-SF-V1 MNA-SF-V2	MNA-LF	RM: 23.3 M: 0.0
Mahdavi, 2015[53]	IR	CD	205	Cluster sampling Markazi Provence	55	73.7 ± 8.9	MNA-SF-V2§	MNA-LF	RM: 37.1 M: 8.3
Rubenstein, 2001[43]	FR ES US	73.8%CD 16.3%H 9.9% NH	881	Toulouse-91, Mataró and the New Mexico Aging Process study	39	76.4 ± NR	MNA-SF	Rating (G) MNA-LF	RM: 25.5 M: 11.2
Sarikaya, 2015[44]	TR	OP	236	Geriatric OP clinic	38	76.4 ± 7.2	MNA-SF MNA-LF	Rating (G)	NR
Suzana, 2007[45]	MY	OP - 44%U 56%R	274	OP clinics or day care centre	44	67.7 ± 5.7	MNA-SF MRST-C MRST-H	BMI MUAC CC	M: 3.8
Sheard, 2013[46]	AU	CD	125	Earlier participants, community groups, advertisement	59	70†,‡	MNA-SF-V1 BMI	SGA	RM: 15 M: 0
Simsek, 2014[47]	TR	CD	640	NR	37	74.1 ± 6.3	MNA-SF-V1 MNA-SF-V2	MNA-LF	RM: 28 M: 2.7
Soderhamn, 2012[48]	NO	CD	2106	Postal questionnaire	50	74.5 ± 6.9	NUFE	MNA-SF	RM: 14
Tomstad, 2013[49]	NO	CD	158	Postal questionnaire	42	73.2 ± 6.9	NUFE	MNA-SF	NR
Tsai, 2009[50]	TW	OP	497	Consecutive OP receiving annual health check-up	45	73.7 ± 6.2	MNA-SF-V1§ MNA-SF-V2§ MUST	MNA-LF§	RM: 13.6 M: 0.5
Wham, 2014[51]	NZ	CD	45	Earlier participants	53	85–86	SCREEN II	Rating (D)	RM: 47 M: 22

Country abbreviations (in order of citation): PL, Poland; ZA, South Africa; ES, Spain; IT; Italy; NP, Nepal; JP, Japan; WAL, Wales; DE, Germany; CA, Canada; CZ, Czech Republic; SK, Slovakia; TW, Taiwan; AU, Australia; NL, Netherlands; BR, Brazil; CU, Cuba; CL, Chile; MX, Mexico; UY, Uruguay; FR, France; IR, Iran; US, United States; TR, Turkey; MY, Malaysia; NO, Norway; NZ, New Zealand.
CC, Calf circumference; CD, Community-Dwellers; DH, Day Hospital; GP, General Practitioner; M, Malnourished; MNA-CC-MAC, Mini Nutritional Assessment in which Body Mass Index is replaced by calf circumference and mid arm circumference; MNA-P, Mini nutritional assessment–proportional; MST, Malnutrition Screening Tool; MUAC, Mid upper arm circumference; NH, Nursing Homes; NR, not reported; NRST, Nutritional Risk Screening Tool; OP, Outpatient; R, rural; Rating (D), Dietitian's Rating; Rating (G), Geriatrician's rating; RM, At risk of malnutrition; SA, Senior's Apartment; SH, Supportive Housing; U, urban.

*Global questions only.
†Median age.
‡Subjective questions only.
§Adapted for specific population.
‖Abbreviated version.

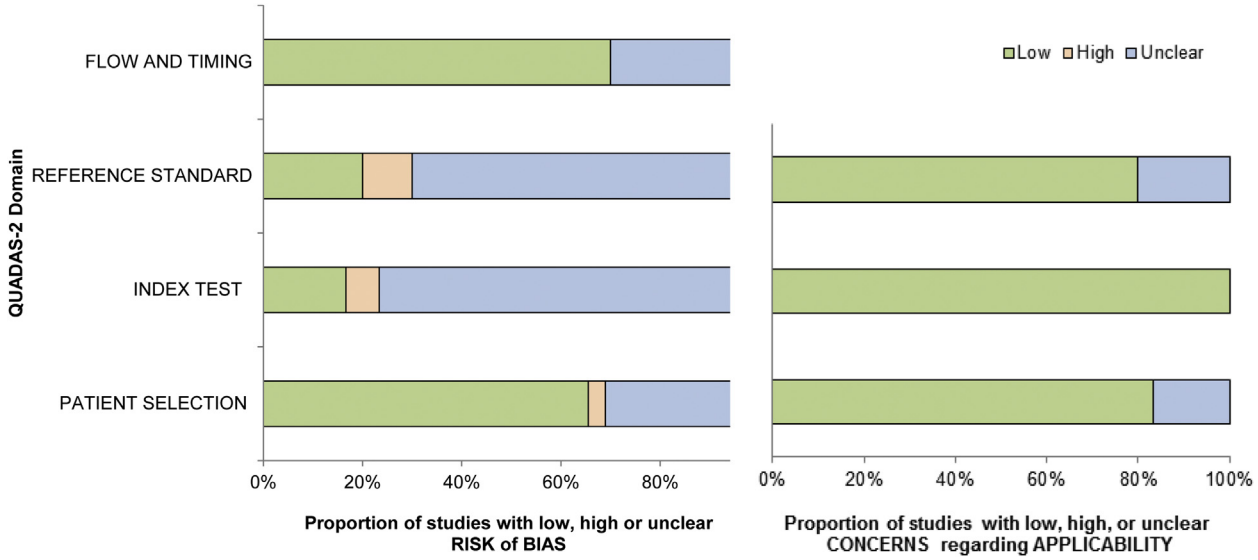

Fig. 2. Methodological quality assessment of included studies using QUADAS-2.

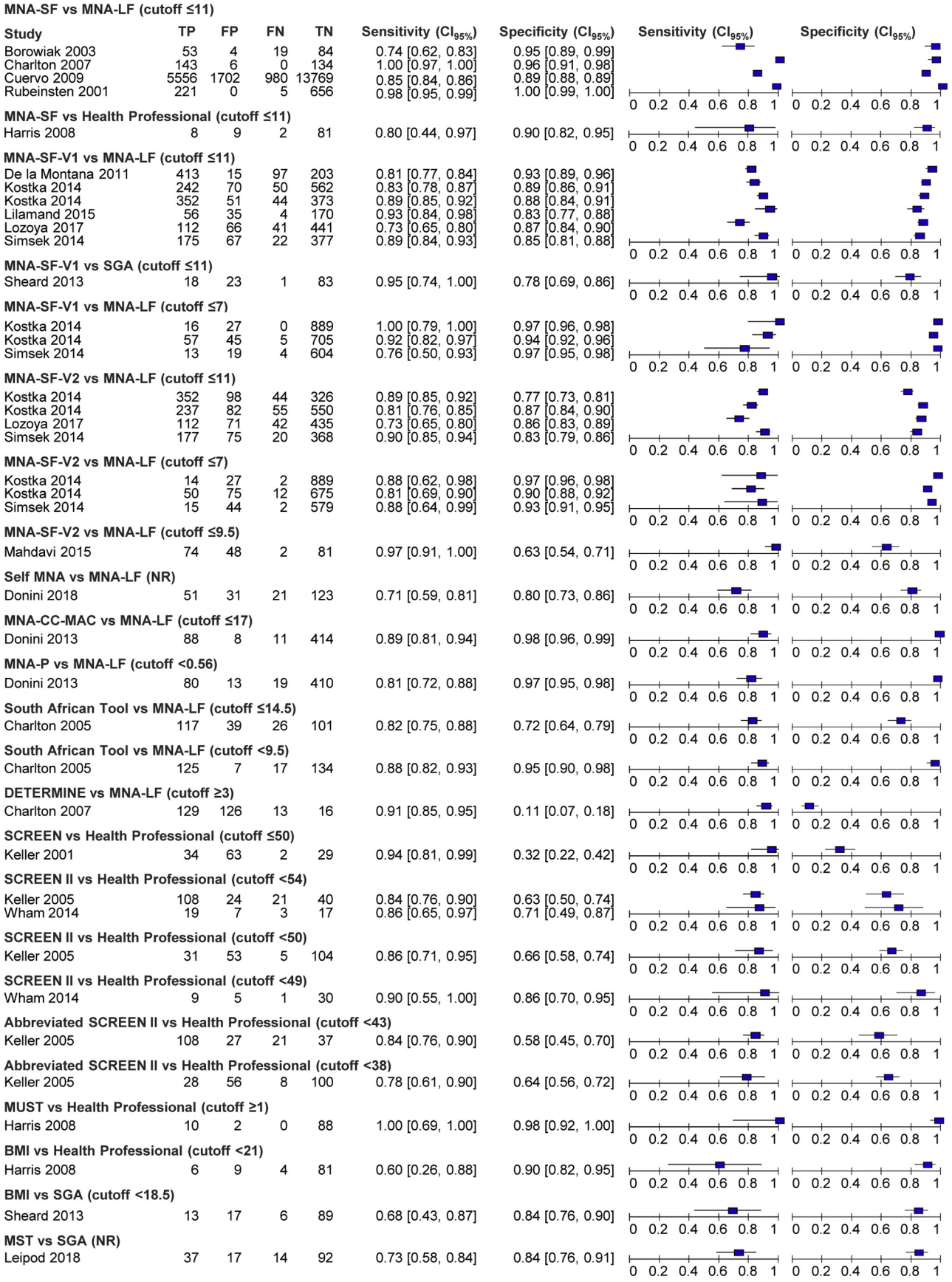

Fig. 3. Forest plots of all nutritional screening tools validated against the MNA-LF, a health professional's rating of nutritional status and the SGA.

Table 3
Diagnostic Performance of Nutritional Screening Tools Identifying Community-Dwelling Older Adults at Risk of Malnutrition or With Malnutrition

Author, Year	Screening Tool (Cutoff)	Reference Standard	SENS, %	SPEC, %	PPV, %	NPV, %	AUC	*r*	κ
MNA-SF, At Risk of Malnutrition									
Borowiak, 2003[21]	MNA-SF (≤11)	MNA-LF	74 (F)	95 (G)	93	82	-	-	-
Charlton, 2007[23]	MNA-SF (≤11)	MNA-LF	100 (G)	96 (G)	16	63	-	0.81* (G)	-
Cuervo, 2009[52]	MNA-SF (≤11)	MNA-LF	85 (G)	89 (G)	76	93	0.94 (G)	0.85* (G)	-
Harris, 2008[29]	MNA-SF (≤11)	Rating (D)	80 (G)	90 (G)	47	98	-	-	-
Suzana, 2007[45]	MNA-SF(≤11)	BMI	100 (G)	74 (F)	21	-	-	0.50*	-
		MUAC	82 (G)	97 (G)	19			0.40*	
		CC	91 (G)	74 (G)	21			0.47*	
Rubenstein, 2001[43]	MNA-SF (≤11)	MNA-LF	98 (G)	100 (G)	-	-	0.96 (G)	0.95* (G)	-
MNA-SF, Malnourished									
Cuervo, 2009[54]	MNA-SF (2.5)†	MNA-LF	90 (G)	85 (G)	21	99	0.96 (G)	-	-
Sarikaya, 2015[44]	MNA-SF (NR)	Rating (G)	94 (G)	81 (G)	80	95	-	-	0.66 (G)
MNA-SF-V1, At Risk of Malnutrition									
De la Montana, 2011[24]	MNA-SF-V1 (≤11)	MNA-LF	81 (G)	93 (G)	96	68	-	0.92* (G)	-
Kaiser, 2011[31]	MNA-SF-V1 (0–7, 8–11, 12–14)	MNA-LF	-	-	-	-	-	-	0.59 (F)
Kostka, 2014[35]	MNA-SF-V1 (≤11)	MNA-LF	U: 83 (G) R: 89 (G)	U: 89 (G) R: 88 (G)	U: 76 R: 84	U: 92 R: 92	-	-	-
Kozakova, 2014[36]	MNA (≤11)	NR	97	57	57	94	-	-	-
Kiesswetter, 2014[34]	MNA-SF-V1 (0–7, 8–11, 12–14)	MNA-LF	-	-	-	-	-	0.89* (G)	0.62 (G)
Tsai, 2009[50]	MNA-SF-V1‡	MNA-LF‡	-	-	-	-	-	-	0.77 (G)
Lee, 2012[37]	MNA-SF-V1‡	MNA-LF‡	-	-	-	-	0.97 (G)	-	-
Lilamand, 2015[41]	MNA-SF-V1 (12)	MNA-LF	76 (F)	96 (G)	84	93	0.95 (G)	-	-
Lilamand, 2015[41]	MNA-SF-V1 (11)	MNA-LF	94 (G)	83 (G)	62	98	0.95 (G)	-	-
Lozoya, 2017[42]	MNA-SF-V1 (≤11)	MNA-LF	73 (F)	87 (G)	62	91	0.88 (G)	0.78* (G)	0.54 (F)
Sheard, 2013[46]	MNA-SF-V1 (≤11)	SGA	95 (G)	78 (G)	58	99	-	-	0.92 (G)
Simsek, 2014[47]	MNA-SF-V1 (≤11)	MNA-LF	89 (G)	85 (G)	70	95	0.87 (G)	0.86* (G)	0.63 (G)
MNA-SF-V1, Malnourished									
Kostka, 2014[35]	MNA-SF-V1 (≤7)	MNA-LF	U: 100 (G) R: 92 (G)	U: 97 (G) R: 94 (G)	U: 37 R: 56	U: 100 R: 99	-	-	-
Simsek, 2014[47]	MNA-SF-V1 (≤7)	MNA-LF	77 (G)	97 (G)	42	99	0.87 (G)	0.86* (G)	0.63 (G)
MNA-SF-V2, At Risk of Malnutrition									
Kaiser, 2011[31]	MNA-SF-V2 (0 – 7; 8- 11; 12–14)	MNA-LF	-	-	-	-	-	-	0.58 (F)
Kostka, 2014[35]	MNA-SF-V2 (≤11)	MNA-LF	U: 81 (G) R: 89 (G)	U: 87 (G) R: 77 (F)	U: 73 R: 73	U: 91 R: 91	-	-	-
Lee, 2012	MNA-SF-V2‡	MNA-LF‡	-	-	-	-	0.97 (G)	-	-
Lera, 2016[40]	MNA-SF-V2 (≤11)	MNA-SF-V1	74–94 (F-G)	73–100 (F-G)	-	-	0.87–0.95 (G)	-	0.62–0.79 (G)
Lozoya, 2017[42]	MNA-SF-V2 (≤11)	MNA-LF	73 (F)	86 (G)	62	91	0.87 (G)	0.78* (G)	0.52 (F)
Mahdavi, 2015	MNA-SF-V2 (≤9.5)	MNA-LF	97 (G)	63 (F)	68	96	0.80(G)	0.87* (G)	0.63 (G)
Simsek, 2014[47]	MNA-SF-V2 (≤11)	MNA-LF	90 (G)	83(G)	67	96	0.86 (G)	0.87* (G)	0.62 (G)
Tsai, 2009[50]	MNA-SF-V2‡ (≤11)	MNA-LF‡	-	-	-	-	-	-	0.75 (G)
Tsai, 2009[50]	MNA-SF-V2‡ (≤11)	MNA-SF-V1‡	-	-	-	-	-	-	0.88 (G)
MNA-SF-V2, Malnourished									
Kostka, 2014[35]	MNA-SF-V2 (≤7)	MNA-LF	U: 88 (G) R: 81 (G)	U: 97 (G) R: 90 (G)	U - 34 R - 40	U - 99 R - 98	-	-	-
Simsek, 2014[47]	MNA-SF-V2 (≤7)	MNA-LF	88 (G)	97 (G)	26	99	0.93 (G)	0.87* (G)	0.62 (G)
Self-MNA, At risk of Malnutrition									
Donini, 2018[26]	Self-MNA (NR)	MNA-LF	71 (F)	80 (G)	68	82	-	-	0.48 (F)
Donini, 2018[26]	Self-MNA (NR)	MNA-SF	75 (F)	82 (G)	65	88	-	-	0.49 (F)
MNA-LF, Malnourished									
Sarikaya, 2015[44]	MNA-LF (NR)	Rating (G)	92 (G)	86 (G)	81	94	-	-	0.68 (G)
Donini, 2013[25]	MNA-CC-MAC (≤17)	MNA-LF	89 (G)	98 (G)	94	94	-	-	-
Donini. 2013[25]	MNA-P (<0.56)	MNA-LF	81 (G)	97 (G)	95	89	-	-	-
Ghimire, 2017[27]	MNA-LF (NR)	BMI	86 (G)	67 (F)	82	72	-	0.58* (P)	-
SCREEN, At risk of Malnutrition									
Keller, 2001[32]	SCREEN (≤50)	Rating (D)	94 (G)	32 (P)	46	86	0.78 (F)	−0.47* (F)	-
SCREEN II, At risk of Malnutrition									
Keller, 2005[33]	SCREEN II (<54)	Rating (D)	84 (G)	62 (F)	85	61	0.82 (G)	−0.62* (F)	-
Keller, 2005[33]	SCREEN II§ <43)	Rating (D)	84 (G)	58 (F)	83	59	0.79 (F)	-	-
Wham, 2014[51]	SCREEN II (<54)	Rating (D)	88 (G)	71 (F)	73	87	0.89 (G)	−0.76* (G)	-
Htun, 2015[30]	SCREEN II‡ (NR)	MNA-SF	-	-	-	-	0.58 (P)	0.22* (P)	-
Htun, 2015[30]	SCREEN II‡ (NR)	GNRI	-	-	-	-	0.64 (F)	0.14* (P)	-
SCREEN II, Malnourished									
Keller, 2005[33]	SCREEN II (<50)	Rating (D)	86 (G)	66 (F)	-	-	0.82 (G)	0.82 (G)	-
Keller, 2005[33]	SCREEN II§ <38)	Rating (D)	77 (F)	64 (F)	-	-	0.78 (F)	-	-
Wham, 2014[51]	SCREEN II (<49)	Rating (D)	90 (G)	86 (G)	64	97	-	−0.76* (G)	-

(*continued on next page*)

Table 3 (*continued*)

Author, Year	Screening Tool (Cutoff)	Reference Standard	SENS, %	SPEC, %	PPV, %	NPV, %	AUC	*r*	κ
NUFE, At risk of Malnutrition									
Soderhamn, 2012[48]	NUFE (≥4)	MNA-SF	71 (F)	74 (F)	30	94	0.71 (F)	−0.37* (P)	-
Tomstad et al, 2013[49]	NUFE (≥4)	MNA-SF	79 (F)	75 (F)	26	97	0.77 (F)	−0.26* (P)	-
MUST, At risk of Malnutrition									
Harris et al, 2008[29]	MUST (≥1)	Rating (D)	100 (G)	98 (G)	83	100	-	-	-
Kozakova, 2014[36]	MUST (NR)	NR	90	88	59	90	-	-	-
Leistra, 2013[39]	MUST (≥1)	weight loss and BMI	64 (F)	96 (G)	76	93	-	-	-
Tsai, 2009[50]	MUST‡	MNA-LF‡	-	-	-	-	-	-	0.48 (F)
MUST, Malnourished									
Leistra, 2013[39]	MUST (≥2)	weight loss and BMI	58 (F)	96 (G)	59	96	-	-	-
SNAQ, At risk of Malnutrition									
Leistra, 2013[39]	SNAQ (≥2)	weight loss and BMI	31 (P)	98 (G)	81	87	-	-	-
Harada, 2017[28]	$SNAQ^{revised}$ (2.5)	CONUT	92 (G)	63 (F)	-	-	0.82 (G)	-	-
SNAQ, Malnourished									
Leistra, 2013[39]	SNAQ (≥3)	weight loss and BMI	42 (P)	99 (G)	76	95	-	-	-
BMI, At risk of Malnutrition									
Harris, 2008[29]	BMI (<21 kg m^2)	Rating (D)	60 (F)	90 (G)	100	96	-	-	-
Sheard, 2013[46]	BMI (<18.5 kg m^2)	SGA	68 (F)	84 (G)	43	94	-	-	0.58 (F)
MRST, At risk of Malnutrition									
Suzana, 2007[45]	MRST-C (≥5)	BMI	30 (P)	90 (G)	17	-	-	-	-
		MUAC	11 (P)	94 (G)	18				
		CC	45 (P)	91 (G)	28				
Suzana, 2007[45]	MRST-H (≥3)	BMI	60 (F)	98 (G)	67	-	-	-	-
		MUAC	55 (F)	98 (G)	67				
		CC	46 (P)	98 (G)	56				
South African Tool, At risk of Malnutrition									
Charlton, 2005[22]	South African Tool (≤14.5)	MNA-LF	82 (G)	72 (F)	76	79	-	0.74* (F)	-
South African Tool, Malnourished									
Charlton, 2005[22]	South African Tool (<9.5)	MNA-LF	88 (G)	95 (G)	41	99	-	-	-
DETERMINE, Malnourished									
Charlton, 2007[23]	DETERMINE (≥3)	MNA-LF	91 (G)	11 (P)	56	50	-	-	-
MST, At risk of Malnutrition									
Leipold, 2018[38]	MST (NR)	SGA	72 (F)	84 (G)	70	85	-	-	-
SGA									
Kozakova, 2012[12]	SGA	BMI	-	-	-	-	-	−0.58 (F)	-
Kozakova, 2014[36]	SGA (NR)	NR	94	70	63	94	-	-	-

CC, Calf circumference; (G), Good rating; (F), Fair rating; MNA-CC-MAC, Mini Nutritional Assessment in which BMI is replaced by calf circumference and mid arm circumference; MNA−P Proportional: Mini nutritional assessment−proportional; MUAC, Mid upper arm circumference; NR, Not reported; (P), Poor rating; R, Rural; Rating (D), Dietitian's rating; Rating (G), Geriatrician's rating; SENS, Sensitivity; SPEC, Specificity; U, Urban.

*$P < .01$.

†Refers to subjective questions of MNA only (self-perception of health - max of 4 points).

‡Adapted for specific population.

§Abbreviated version.

Screening Tool,[30] SCREEN version I[32] and II,[33,51] Japanese adaptation of SCREEN II,[32] Malnutrition Universal Screening Tool (MUST),[36,39,45,50] Short Nutritional Assessment Questionnaire (SNAQ),[28,55] BMI,[29,46] Nutritional form for the elderly (NUFE),[48,49] and Malnutrition Screening Tool.[38]

Quality Assessment

Figure 2 shows the methodological quality assessment of the studies. Most articles did not specify if the researchers interpreted the nutritional screening tools without knowledge of the results of the reference standard and vice versa. Therefore, the risk of bias for the interpretation of the index test and the reference standard was often unclear (70% and 67%, respectively). Ten reference standards were identified. The reference standard varied widely between studies: MNA-LF,[21,23–26,31,34,35,37,41–43,47,50,52–54] dietitian's or physician's rating,[29,32,33,44,51] SGA,[38,46] Anthropometry−BMI,[27,45] calf circumference and mid upper arm circumference,[45] self-reported unintentional weight loss and BMI,[39] MNA-SF,[26,30,48,49] MNA-SF-V1,[40,50] Geriatric Nutrition Risk Index (GNRI),[30] and CONUT.[28] Ten of 34 articles used a reference standard other than the MNA-LF, a health professional's rating of nutritional status, or SGA.

Diagnostic Performance of Nutritional Screening Tools in Community-dwelling Older Adults Based on the Systematic Review

Figure 3 displays the sensitivity and specificity of all nutritional screening tools validated against the MNA-LF, SGA, or a health professional's rating of nutritional status. The most frequently tested nutritional screening tools compared with the MNA-LF or health professional were the MNA-SF, MNA-SF-V1, MNA-SF-V2, and SCREEN II. On the MNA-SF, MNA-SF-V1, and MNA-SF V2, the cutoff point ≤11 was used to identify individuals at risk of malnutrition, whereas the cutoff point ≤7 was used to identify those with malnutrition on the

Table 4
Summary of Diagnostic Accuracy of Nutritional Screening Tools for Identifying Community-Dwelling Older Adults

Nutritional Screening Tool and Cutoff	Summary Estimate (95% CI)
MNA-SF (≤11)	Sensitivity: 0.95 (0.75–0.99) Specificity: 0.95 (0.85–0.99) DOR: 1062.34 (38.86–29039.22) LR+: 49.06 (5.76–417.69) LR−: 0.05 (0.01–0.30)
MNA-SF-V1 (≤11)	Sensitivity: 0.85 (0.80–0.89) Specificity: 0.87 (0.85–0.89) DOR: 40.84 (29.11–57.29) LR+: 6.82 (5.85–7.96) LR−: 0.17 (0.12–0.23)
MNA-SF-V2 (≤11)	Sensitivity: 0.85 (0.77–0.89) Specificity: 0.84 (0.79–0.87) DOR: 27.04 (19.81–36.90) LR+: 5.13 (4.29–6.15) LR−: 0.19 (0.14–0.27)

95% CI, 95% Confidence Interval; LR+, Likelihood ratio for a positive test; LR−, Likelihood ratio for a negative test result.

MNA-SF-V1 and MNA-SF-V2. On the MNA-SF, the sensitivity of the cutoff point ≤11 ranged from 74% to 100% and the specificity ranged from 89% to 100%. On the MNA-SF-V1, the sensitivity of the cutoff point ≤11 ranged from 73% to 93% and specificity ranged from 85% to 93%, whereas the sensitivity of cutoff point ≤7 ranged from 76% to 100%, and specificity ranged from 94% to 87%. On the MNA-SF-V2, the cutoff point ≤11 ranged from 73% to 90% and specificity ranged from 77% to 86%, whereas the cutoff point ≤7 ranged from 81% to 88% and specificity from 90% to 97%. SCREEN II was validated against a dietitian's rating of nutritional status in 2 articles, the cutoff points <54 was used to identify older adults at risk of malnutrition. Both of these studies showed good sensitivity (84% and 88%) and fair specificity (62% and 71%). The Self MNA, MNA-CC-MAC, MNA-P, the South African tool, DETERMINE, SCREEN, Abbreviated SCREEN II, MUST, BMI, and Malnutrition Screening Tool (MST) were compared with the MNA-LF, health professionals' rating, or SGA in only 1 study.

Table 3 lists the sensitivity, specificity, PPV, NPV, AUC, correlation coefficient, and kappa of each nutritional screening tool as well as the cutoff points compared with a reference standard. In community-dwelling older adults, the MUST was validated against self-reported weight loss and measured BMI,[39] MNA-LF,[50] and a dietitian's rating of nutritional risk.[29] The reported sensitivity of the MUST to identify individuals at risk of malnutrition varied greatly between these studies (64% vs. 100%); however, specificity was high in both studies (96% and 98%). The nutritional tool SNAQ was validated against both self-reported unintentional weight loss and measured BMI,[39] and CONUT.[28] The sensitivity and specificity of the SNAQ varied widely between these studies (31% vs. 92%) and (98% vs. 63%), respectively. The NUFE tool was validated against another nutritional screening tool, that is, MNA-SF, and the NUFE was reported to have fair sensitivity, specificity, and AUC compared with the MNA-SF.[48,49] The use of BMI and SGA was used interchangeably as a nutritional screening tool[29,46] and a reference standard.[27,45] Sheard et al.[46] validated BMI against SGA, whereas Kozakova et al.[36] validated SGA against BMI. In community-dwelling older adults, the following nutritional screening tools were validated in only 1 study: SCREEN,[32] self-MNA,[26] DETERMINE,[23] South African Tool,[22] MRST-Community (MRST-C) and MRST-Hospital (MRST-H),[45] and MST.[38]

Meta-analysis of the Diagnostic Accuracy of the MNA-SF, MNA-SF-V1 and MNA-SF-V2 to Identify Risk of Malnutrition in Community-dwelling Older Adults

All articles identified used the cutoff point ≤11 to identify community-dwelling older adults at risk of malnutrition on the MNA-SF, MNA-SF-V1, and MNA-SF-V2. These nutritional screening tools were all validated against the MNA-LF and the TP, FN, TN, and FP sensitivity and specificity of each study is displayed in forest plots in Figure 3. The pooled sensitivity, specificity, DOR, positive likelihood ratio, negative likelihood ratio of the cutoff point ≤11 on the MNA-SF, MNA-SF-V1, and MNA-SF-V2 are shown in Table 4. The MNA-SF had a sensitivity of 0.95 (95% CI 0.75–0.99) and specificity was 0.95 (95% CI 0.85–0.99). The summary estimate for sensitivity on MNA-SF-V1 was 0.85 (95% CI 0.80–0.89) and specificity was 0.87 (95% CI 0.85–0.89). The pooled sensitivity of the MNA-SF-V2 was 0.85 (95% CI 0.77–0.89) and specificity was 0.84 (95% CI 0.79–0.87). The hierarchical summary receiver operating characteristic curves for the MNA-SF, MNA-SF-V1, and MNA-SF-V2 at the cutoff point of ≤11 is shown in Figure 4.

Discussion

The nutritional screening tools that displayed good sensitivity and at least fair specificity were the MNA-SF, MNA-SF-V1 and MNA-SF-V2, and SCREEN II. The meta-analyses showed high sensitivity and specificity for MNA-SF, MNA-SF-V1, and MNA-SF-V2 screening tools validated against the MNA-LF identifying community-dwelling older adults at risk of malnutrition.

The MNA-SF was developed in 2001 and consists of 6 questions; a score of ≤11 points classifies individuals as at risk of malnutrition. The meta-analysis showed that the MNA-SF had good sensitivity and specificity for the cutoff point of ≤11; however, the 95% CI was wide. In 2009, the MNA-SF was revised by Kaiser et al.,[56] which led to a 3-category system: "malnourished ≤7"; "at risk of malnutrition 8–11"; and "normal nutritional status 12–14". Kaiser et al.[56] suggested 2 versions of the revised MNA-SF, that is, MNA-SF-V1 which includes BMI or MNA-SF-V2 in which calf-circumference is used when BMI cannot be calculated.[56] Our meta-analysis demonstrated that the cutoff point ≤11 on both the MNA-SF-V1 and MNA-SF-V2 had a good sensitivity, specificity, and a narrow 95% CI. There were an insufficient number of studies that reported the sensitivity and specificity of the cutoff of ≤7 points on the MNA-SF-V1 and MNA-SF-V2 to identify malnutrition in community-dwelling older adults. Overall, our findings suggest that the MNA-SF-V1 and MNA-SF-V2, a simple, quick and effective screening tool, can identify community-dwelling older adults at risk of malnutrition.

In a recent review, SCREEN II was suggested as the most appropriate tool in community-dwelling older adults[15]; however, it should be noted that this tool was validated in only 2 studies including small populations.[33,51] The cutoff of <54 points was previously recommended to detect the risk of malnutrition, and our results show that this cutoff point has good sensitivity but only fair specificity in community-dwelling older adults. The fair specificity would suggest that this screening tool would identify many false positive tests when identifying individuals at risk of malnutrition. To improve on the sensitivity and specificity, lower cutoff points were suggested, such as cutoff of <50 points[33] and cutoff of <49 points.[51] Although the cutoff of <49 points on SCREEN II showed good sensitivity and specificity when identifying older adults with malnutrition, this cutoff point was only validated in a small sample size ($n = 45$). Therefore, larger studies are needed to further validate the use of this cutoff point in community-dwelling older adults.

When choosing a nutritional screening tool to identify individuals at risk of malnutrition, it is important to ensure that the nutritional screening tool accurately identifies individuals at risk of, or with, malnutrition. However, one of the major limitations is that there is no "gold standard" for the diagnostic criteria for malnutrition. Indeed, we identified 10 different reference standards in this review alone. When assessing the quality of the studies, we reasoned that the MNA-LF, dietitian/physician's rating of nutritional status, or SGA would be most likely to correctly identify patients at risk of malnutrition or with

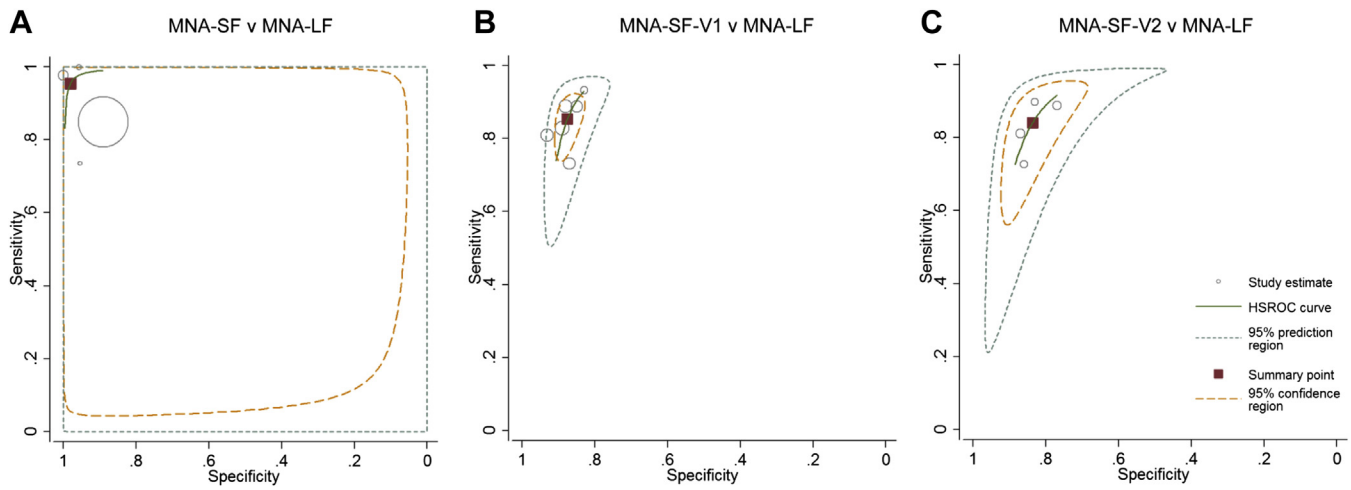

Fig. 4. Pooled sensitivity, specificity, and HSROC curve for screening for the risk of malnutrition using the cutoff point ≤11 on the MNA-SF (A), MNA-SF-V1 (B), and MNA-SF-V2 (C) compared with the MNA-LF. MNA-SF: left, number of articles = 4, number of participants = 23,331; MNA-SF-V1 using BMI: middle, number of articles = 6, number of participants = 4037); MNA-SF-V2 using calf-circumference instead of BMI: right, number of articles = 4, number of participants = 2384).

malnutrition. However, it should be noted that in recent years, societies such as The European Society of Clinical Nutrition and Metabolism (ESPEN)[57] and, more recently, the Global Leadership Initiative on Malnutrition (GLIM) proposed consensus schemes for diagnosing malnutrition.[57,58] To our knowledge there are a growing number of studies evaluating the ESPEN definition of malnutrition[5,13] and no studies that have validated any nutritional screening tools against the GLIM definition of malnutrition in community-dwelling older adults.

Risk of Bias

It was often unclear whether the nutritional screening tools were interpreted without knowledge of the results of the reference standard and vice versa. The lack of blinding may have inflated the diagnostic accuracy of the nutritional screening tool. It is recommended for future studies to be more transparent in their methodology and provide details on whether assessors were blinded to the index test results and vice versa. To reduce the risk of bias, investigators should follow the guidelines described by the Standards for Reporting of Diagnostic Accuracy Studies.[59] In addition, a high risk of bias was considered if a single measurement such as BMI was the reference standard and if a nutritional screening tool was considered as the reference standard (eg, MNA-SF). Interestingly, the MNA-SF, MNA-LF, and SGA were interchangeably used as either the index test (screening tool) or the reference standard (assessment tool).

Strengths and Limitations

The strengths of this systematic review were that we identified (1) all nutritional screening tools validated against a reference standard, (2) the cutoff points that were validated to identify community-dwelling older adults at risk of malnutrition or with malnutrition, and (3) summarized the results in a meta-analysis. To our knowledge, this is the first meta-analysis on the diagnostic accuracy of nutritional screening tools used to identify community-dwelling older adults at risk of malnutrition and those with malnutrition. However, a limitation of our study is that our search strategy started after 2001; therefore any validity studies before that time were excluded. Furthermore, it was out of the scope of this review to describe reliability, repeatability, and predictive validity of the nutritional screening tools.

Conclusions and Implications

This systematic review further highlights that there is a need for a universal gold standard for the diagnostic criteria of malnutrition. The results from this meta-analysis show evidence for the use of the cutoff of ≤11 points on the MNA-SF or MNA-SF-V1 or MNA-SF-V2 to detect community-dwelling older adults at risk of malnutrition. Although, it should be noted that we were unable to analyze the other cutoff points on these nutritional screening tools. Overall, our results suggest that, if scales and stadiometers are available in the community setting and thus BMI can be calculated, then the MNA-SF-V1 should be used. Otherwise, if a scale is not available then calf circumference should be obtained, and the MNA-SF-V2 should be used to identify community-dwelling older adults at risk of malnutrition or with malnutrition. Further research is needed in community-dwelling older adults on the validity of the other available nutritional screening tools, such as SCREEN II and NUFE.

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Supplementary Data

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Appendix 1.
Search Syntax

PubMed:

#1 "Malnutrition"[Mesh:NoExp] OR "Protein Deficiency"[Mesh] OR "Nutritional Status"[Mesh] OR "Nutrition Assessment"[Mesh] OR malnutrition[tiab] OR undernutrition[tiab] OR under-nutrition[tiab] OR nutritional deficienc*[tiab] OR nutrition deficienc*[tiab] OR depletion[tiab] OR underfeeding[tiab] OR malnourish*[tiab] OR undernourish*[tiab] OR under nourish*[tiab] OR protein deficienc*[tiab] OR energy deficienc*[tiab] OR nutritional risk*[tiab] OR nutritional stat*[tiab] OR nutrition stat*[tiab]

#2 "Aged"[Mesh] OR "Geriatrics"[Mesh] OR aged[tiab] OR elder*[tiab] OR older people[tiab] OR older person*[tiab] OR geriatric[tiab]OR geriatrics[tiab] OR ageing[tiab] OR aging[tiab] OR eldest[tiab] OR frail*[tiab] OR old age*[tiab] OR oldest old*[tiab] OR older subject*[tiab] OR older patient*[tiab] OR older age*[tiab] OR older man[tiab] OR older men[tiab] OR older male[tiab] OR older woman[tiab] OR older women[tiab] OR older female[tiab] OR pensioner*[tiab] OR retired[tiab] OR senior*[tiab] OR very old*[tiab] OR septuagenarian*[tiab] OR octagenarian*[tiab] OR octogenarian*[tiab] OR nonagenarian*[tiab] OR centarian*[tiab] OR centenarian*[tiab] OR supercentenarian*[tiab] OR older adult*[tiab] OR older population*[tiab] OR older person*[tiab] OR old person [tiab]

#3 "Nutrition Assessment"[Mesh] OR "Nutrition Surveys"[Mesh] OR "Geriatric Assessment"[Mesh] OR assess*[tiab] OR instrument*[tiab] OR measure*[tiab] OR survey*[tiab] OR questionnair*[tiab] OR screen[tiab] OR screening[tiab] OR screener[tiab] OR self-report*[tiab] OR scale[tiab] OR scales[tiab] OR tool[tiab] OR tools[tiab] OR evaluation[tiab] OR score*[tiab] OR scoring[tiab] OR index[tiab] OR "Validation Studies"[pt] OR "Comparative Study"[pt] OR clinimetr*[tw] OR clinometr*[tw] OR "outcome assessment (health care)"[MeSH:noexp] OR outcome measure*[tw] OR reliab*[tiab] OR unreliab*[tiab] OR valid*[tiab] OR coefficient[tiab] OR internal consistency[tiab] OR (item [tiab] AND (correlation*[tiab] OR selection*[tiab] OR reduction*[tiab])) OR agreement[tw] OR test-retest[tiab] OR (test[tiab] AND retest[tiab]) OR (reliab*[tiab] AND (test[tiab] OR retest[tiab])) OR stability[tiab] OR interrater[tiab] OR inter-rater[tiab] OR intrarater[tiab] OR intra-rater [tiab] OR repeatab*[tiab] OR specificit*[tiab] OR sensitiv*[tiab] OR responsive*[tiab] OR ((replicab*[tw] OR repeated[tw]) AND (measure*[tw] OR findings[tw] OR result[tw] OR results[tw] OR test[tw] OR tests [tw])) OR concordance[tiab] OR (intraclass[tiab] AND correlation*[tiab])

#4 "Activities of Daily Living"[Mesh] OR "Outpatients"[Mesh] OR "Independent Living"[Mesh] OR communit*[tiab] OR aging in place[tiab] OR ageing in place[tiab] OR independent living[tiab] OR living independent*[tiab] OR living autonomous*[tiab] OR autonomous living*[tiab] OR home[tiab] OR home-based[tiab] OR homecare[tiab] OR house-based[tiab] OR homebased[tiab] OR domicil*[tiab] OR noninstitutionalized[tiab] OR non-institutionalized[tiab] OR home-dwelling[tiab] OR homedwelling [tiab] OR outpatient*[tiab] OR out-patient*[tiab] OR healthy[tiab] OR discharge*[tiab]

#5 #1 AND #2 AND #3 AND #4

#6 NOT (("Adolescent"[Mesh] OR "Child"[Mesh] OR "Infant"[Mesh] OR adolescen*[tiab] OR child*[tiab] OR schoolchild*[tiab] OR infant*[tiab] OR girl*[tiab] OR boy*[tiab] OR teen[tiab] OR teens [tiab] OR teenager*[tiab] OR youth*[tiab] OR pediatr*[tiab] OR paediatr*[tiab] OR puber*[tiab]) NOT ("Adult"[Mesh] OR adult*[tiab] OR man[tiab] OR men[tiab] OR woman[tiab] OR women [tiab]))

Embase:

#1 'malnutrition'/de OR 'protein deficiency'/exp OR 'nutritional status'/exp OR 'nutritional assessment'/exp OR malnutrition:ab,ti,kw OR undernutrition:ab,ti,kw OR 'under-nutrition':ab,ti,kw OR 'nutrition* deficienc*':ab,ti,kw OR depletion:ab,ti,kw OR underfeeding:ab,ti,kw OR malnourish*:ab,ti,kw OR undernourish*:ab,ti,kw OR 'under-nourish*':ab,ti,kw OR 'protein deficienc*':ab,ti,kw OR 'energy deficienc*':ab,ti,kw OR 'nutritional risk*':ab,ti,kw OR 'nutrition* stat*':ab,ti,kw

#2 'aged'/exp OR 'geriatrics'/exp OR elder*:ab,ti,kw OR eldest:ab,ti,kw OR frail*:ab,ti,kw OR geriatric:ab,ti,kw OR geriatrics:ab,ti,kw OR 'old* age*':ab,ti,kw OR 'oldest old*':ab,ti,kw OR 'older subject*':ab,ti,kw OR 'older patient*':ab,ti,kw OR 'old* adult*':ab,ti,kw OR 'older man':ab,ti,kw OR 'older men':ab,ti,kw OR 'older male*':ab,ti,kw OR 'older woman':ab,ti,kw OR 'older women':ab,ti,kw OR 'older female*':ab,ti,kw OR 'old* population*':ab,ti,kw OR 'old* person*':ab,ti,kw OR pensioner*:ab,ti,kw OR retired:ab,ti,kw OR senior*:ab,ti,kw OR 'very old*':ab,ti,kw OR septuagenarian*:ab,ti,kw OR octagenarian*:ab,ti,kw OR octogenarian*:ab,ti,kw OR nonagenarian*:ab,ti,kw OR centarian*:ab,ti,kw OR centenarian*:ab,ti,kw OR supercentenarian*:ab,ti,kw OR 'older people':ab,ti,kw OR 'old* adult*':ab,ti,kw

#3 'nutritional assessment'/exp OR 'geriatric assessment'/exp OR 'questionnaire'/exp OR 'validation study'/exp OR 'comparative study'/exp OR 'outcome assessment'/exp OR assess*:ab,ti,kw OR screening:ab,ti,kw OR instrument*:ab,ti,kw OR measure*:ab,ti,kw OR survey*:ab,ti,kw OR questionnair*:ab,ti,kw OR screen:ab,ti,kw OR screener:ab,ti,kw OR self-report*:ab,ti,kw OR scale:ab,ti,kw OR scales:ab,ti,kw OR tool:ab,ti,kw OR tools:ab,ti,kw OR evaluation:ab,ti,kw OR score*:ab,ti,kw OR scoring:ab,ti,kw OR index:ab,ti,kw OR reliab*:ab,ti,kw OR unreliab*:ab,ti,kw OR valid*:ab,ti,kw OR coefficient:ab,ti,kw OR 'internal consistency':ab,ti,kw OR (item:ab,ti,kw AND (correlation*:ab,ti,kw OR selection*:ab,ti,kw OR reduction*:ab,ti,kw)) OR agreement:ab,ti,kw OR test-retest:ab,ti,kw OR (test:ab,ti,kw AND retest:ab,ti,kw) OR (reliab*:ab,ti,kw AND (test:ab,ti,kw OR retest:ab,ti,kw)) OR stability:ab,ti,kw OR interrater:ab,ti,kw OR 'inter-rater':ab,ti,kw OR intrarater:ab,ti,kw OR 'intra-rater':ab,ti,kw OR repeatab*:ab,ti,kw OR specificit*:ab,ti,kw OR sensitiv*:ab,ti,kw OR responsive*:ab,ti,kw OR ((replicab*:ab,ti,kw OR repeated:ab,ti,kw) AND (measure*:ab,ti,kw OR findings:ab,ti,kw OR result:ab,ti,kw OR results:ab,ti,kw OR test:ab,ti,kw OR tests:ab,ti,kw)) OR concordance:ab,ti,kw OR (intraclass:ab,ti,kw AND correlation*:ab,ti,kw)

#4 'outpatient'/exp OR 'independent living'/exp OR communit*:ab,ti,kw OR 'aging in place':ab,ti,kw OR 'ageing in place':ab,ti,kw OR (independent* NEAR/3 living):ab,ti,kw OR (living NEAR/3 autonom*):ab,ti,kw OR home:ab,ti,kw OR 'home-based':ab,ti,kw OR homecare:ab,ti,kw OR 'house-based':ab,ti,kw OR homebased:ab,ti,kw OR domicil*:ab,ti,kw OR noninstitutionalized:ab,ti,kw OR 'non-institutionalized':ab,ti,kw OR 'home-dwelling':ab,ti,kw OR home-dwelling:ab,ti,kw OR outpatient*:ab,ti,kw OR 'out-patient*':ab,ti,kw OR healthy:ab,ti,kw OR discharge*:ab,ti,kw

#5 #1 AND #2 AND #3 AND #4

#6 NOT (('adolescent'/exp OR 'child'/exp OR adolescent*:ab,ti,kw OR child*:ab,ti,kw OR schoolchild*:ab,ti,kw OR infant*:ab,ti,kw OR girl*:ab,ti,kw OR boy*:ab,ti,kw OR teen:ab,ti,kw OR teens:ab,ti,kw OR teenager*:ab,ti,kw OR youth*:ab,ti,kw OR pediatr*:ab,ti,kw OR paediatr*:ab,ti,kw OR puber*:ab,ti,kw) NOT ('adult'/exp OR 'aged'/exp OR 'middle aged'/exp OR adult*:ab,ti,kw OR man:ab,ti,kw OR men:ab,ti,kw OR woman:ab,ti,kw OR women:ab,ti,kw))

#7 #5 NOT (('adolescent'/exp OR 'child'/exp OR adolescent*:ab,ti,kw OR child*:ab,ti,kw OR schoolchild*:ab,ti,kw OR infant*:ab,ti,kw OR girl*:ab,ti,kw OR boy*:ab,ti,kw OR teen:ab,ti,kw OR teens:ab,ti,kw OR teenager*:ab,ti,kw OR youth*:ab,ti,kw OR

pediatr*:ab,ti,kw OR paediatr*:ab,ti,kw OR puber*:ab,ti,kw) NOT ('adult'/exp OR 'aged'/exp OR 'middle aged'/exp OR adult*:ab,ti,kw OR man:ab,ti,kw OR men:ab,ti,kw OR woman:ab,ti,kw OR women:ab,ti,kw)) AND [2001–2018]/py

#8 #7 NOT ('conference abstract'/it OR 'conference review'/it OR 'editorial'/it OR 'note'/it OR 'short survey'/it)

CINAHL:

S1 MH ("Malnutrition" OR "Protein Deficiency+" OR "Nutritional Status" OR "Nutritional Assessment") OR TI (malnutrition OR undernutrition OR under-nutrition OR nutritional deficienc* OR nutrition deficienc* OR depletion OR underfeeding OR malnourish* OR undernourish* OR under nourish* OR protein deficienc* OR energy deficienc* OR nutritional risk* OR nutritional stat* OR nutrition stat*) OR AB (malnutrition OR undernutrition OR under-nutrition OR nutritional deficienc* OR nutrition deficienc* OR depletion OR underfeeding OR malnourish* OR undernourish* OR under nourish* OR protein deficienc* OR energy deficienc* OR nutritional risk* OR nutritional stat* OR nutrition stat*)

S2 MH ("Aged+" OR "Aged, 80 and Over" OR "Frail Elderly" OR "Geriatrics") OR TI (elder* OR eldest OR frail* OR geriatri* OR "old age*" OR "oldest old*" OR senior* OR senium OR "very old*" OR septuagenarian* OR octagenarian* OR octogenarian* OR nonagenarian* OR centarian* OR centenarian* OR supercentenarian* OR "older people" OR "older subject*" OR "older patient*" OR "older age*" OR "older adult*" OR "older man" OR "older men" OR "older male" OR "older woman" OR "older women" OR "older female" OR "older population*" OR "older person*" OR senior OR pensioner* OR retired OR "very old") OR AB (elder* OR eldest OR frail* OR geriatri* OR "old age*" OR "oldest old*" OR senior* OR senium OR "very old*" OR septuagenarian* OR octagenarian* OR octogenarian* OR nonagenarian* OR centarian* OR centenarian* OR supercentenarian* OR "older people" OR "older subject*" OR "older patient*" OR "older age*" OR "older adult*" OR "older man" OR "older men" OR "older male" OR "older woman" OR "older women" OR "older female" OR "older population*" OR "older person*" OR senior OR pensioner* OR retired OR "very old")

S3 MH ("Nutritional Assessment" OR "Geriatric Assessment" OR "Surveys" OR "Questionnaires" OR "Validation Studies" OR "Comparative Studies" OR "Outcome Assessment") OR TI (assess* OR screening OR instrument* OR measure* OR survey* OR questionnair* OR screen OR screener OR self-report* OR scale OR scales OR tool OR tools OR evaluation OR score* OR scoring OR index OR reliab* OR unreliab* OR valid* OR coefficient OR 'internal consistency' OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR 'inter-rater' OR intrarater OR 'intra-rater' OR repeatab* OR specificit* OR sensitiv* OR responsive* OR ((replicab* OR repeated) AND (measure* OR findings OR result OR results OR test OR tests)) OR concordance OR (intraclass AND correlation*)) OR AB (assess* OR screening OR instrument* OR measure* OR survey* OR questionnair* OR screen OR screener OR self-report* OR scale OR scales OR tool OR tools OR evaluation OR score* OR scoring OR index OR reliab* OR unreliab* OR valid* OR coefficient OR 'internal consistency' OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR test-retest OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR 'inter-rater' OR intrarater OR 'intra-rater' OR repeatab* OR specificit* OR sensitiv* OR responsive* OR ((replicab* OR repeated) AND (measure* OR findings OR result OR results OR test OR tests)) OR concordance OR (intraclass AND correlation*))

S4 MH ("Outpatients" OR "Community Living") OR TI (communit* OR "aging in place" OR "ageing in place" OR (living N3 independent*) OR (living N3 autonomous*) OR home OR home-based OR homecare OR house-based OR homebased OR domicil* OR noninstitutionalized OR non-institutionalized OR home-dwelling OR homedwelling OR outpatient* OR out-patient* OR healthy OR discharge*) OR AB (communit* OR "aging in place" OR "ageing in place" OR (living N3 independent*) OR (living N3 autonomous*) OR home OR home-based OR homecare OR house-based OR homebased OR domicil* OR noninstitutionalized OR non-institutionalized OR home-dwelling OR homedwelling OR outpatient* OR out-patient* OR healthy OR discharge*)

S5 S1 AND S2 AND S3 AND S4

S6 S5 NOT ((ZG ("adolescent: 13–18 years" OR "child, preschool: 2–5 years" OR "child: 6–12 years" OR "fetus, conception to birth" OR "infant, newborn: birth-1 month" OR "infant: 1–23 months") OR TI (adolescen* OR child* OR schoolchild* OR infant* OR girl* OR boy* OR teen OR teens OR teenager* OR youth* OR pediatr* OR paediatr* OR puber*) OR AB (adolescen* OR child* OR schoolchild* OR infant* OR girl* OR boy* OR teen OR teens OR teenager* OR youth* OR pediatr* OR paediatr* OR puber*)) NOT (ZG ("adult: 19–44 years" OR "aged, 80 & over" OR "aged: 65+ years" OR "middle aged: 45–64 years") OR TI (adult* OR man OR men OR woman OR women) OR AB (adult* OR man OR men OR woman OR women)))

S7 S5 AND - Published Date: 20010101–20181231

Cochrane:

#1 malnutrition OR undernutrition OR "under-nutrition" OR "nutritional deficienc*" OR "nutrition deficienc*" OR depletion OR underfeeding OR malnourish* OR undernourish* OR "under nourish*" OR "protein deficienc*" OR "energy deficienc*" OR "nutritional risk*" OR "nutritional stat*" OR "nutrition stat*":ti,ab,kw

#2 elder* OR eldest OR frail* OR geriatri* OR "old age*" OR "oldest old*" OR senior* OR senium OR "very old*" OR septuagenarian* OR octagenarian* OR octogenarian* OR nonagenarian* OR centarian* OR centenarian* OR supercentenarian* OR "older people" OR "older subject*" OR "older patient*" OR "older age*" OR "older adult*" OR "older man" OR "older men" OR "older male" OR "older woman" OR "older women" OR "older female" OR "older population*" OR "older person*" OR senior OR pensioner* OR retired OR "very old":ti,ab,kw

#3 assess* OR screening OR instrument* OR measure* OR survey* OR questionnair* OR screen OR screener OR self-report* OR scale OR scales OR tool OR tools OR evaluation OR score* OR scoring OR index OR reliab* OR unreliab* OR valid* OR coefficient OR "internal consistency" OR (item AND (correlation* OR selection* OR reduction*)) OR agreement OR "test-retest" OR (test AND retest) OR (reliab* AND (test OR retest)) OR stability OR interrater OR "inter-rater" OR intrarater OR "intra-rater" OR repeatab* OR specificit* OR sensitiv* OR responsive* OR ((replicab* OR repeated) AND (measure* OR findings OR result OR results OR test OR tests)) OR concordance OR (intraclass AND correlation*) :ti,ab,kw

#4 communit* OR "aging in place" OR "ageing in place" OR (living NEAR/3 independent*) OR (living NEAR/3 autonomous*) OR home OR home-based OR homecare OR house-based OR homebased OR domicil* OR noninstitutionalized OR non-institutionalized OR home-dwelling OR homedwelling OR outpatient* OR out-patient* OR healthy OR discharge*:ti,ab,kw

#5 #1 AND #2 AND #3 AND #4 #6#5 AND Publication Year from 2001 to 2018